(12) UK Patent Application (19) GB (11) 2 317 139 (13) A

(43) Date of A Publication 18.03.1998

(21) Application No 9719255.3

(22) Date of Filing 11.09.1997

(30) Priority Data
(31) 9618926 (32) 11.09.1996 (33) GB

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(51) INT CL^6
B29C 47/00 // B29C 47/60 47/62 47/64 , C08L 23/08 23/12 23/26 , B29K 105:24

(52) UK CL (Edition P)
B5A AD32 AT17D A1R314C1C A1R314C4 A1R439E A2A1 A20T17
C3M MXAS M140 M144B M300

(56) Documents Cited
GB 1367083 A GB 1246222 A WO 88/01227 A1
US 5384369 A
RD 37155, 371, March 1995, page 228, item no. 37155

(58) Field of Search
UK CL (Edition O) B5A AC AD32 AT17D AT17J AT17R , C3M ML
INT CL^6 B29C 47/00 47/38 47/60 47/62 47/64 , C08L 43/04
Online: WPI

(54) Mixing in an extruder for a cable-making process

(57) An on-line compounding process for making a strippable screen in the manufacture of an electric power cable having insulation of an ethylene homopolymer or copolymer crosslinked via silane links comprises: feeding to an extruder

(a) a preformed composition comprising an ethylene copolymer and carbon black;
(b) particulate polypropylene; and
(c) crosslinking agents comprising an unsaturated hyrolysable silane, a grafting initiator and a silanol condensation catalyst;

mixing these ingredients and generating pressure in the resulting mixture in a first zone of the extruder at a temperature above the softening range of the copolymer but substantially below the softening range of the polypropylene so that it is dispersed in the solid state into the plastified copolymer;

and only after the crosslinking agents at least are dispersed through the mixture raising the temperature of the mixture in a second section of the extruder above the softening range of the polypropylene and sufficient to initiate grafting of silane side-chains to the copolymer and blending to further disperse the now molten polypropylene.

Insulation of the cable may be performed by coextrusion with the insulation and conductor screen in a triple extrusion head. The copolymer is EVA.

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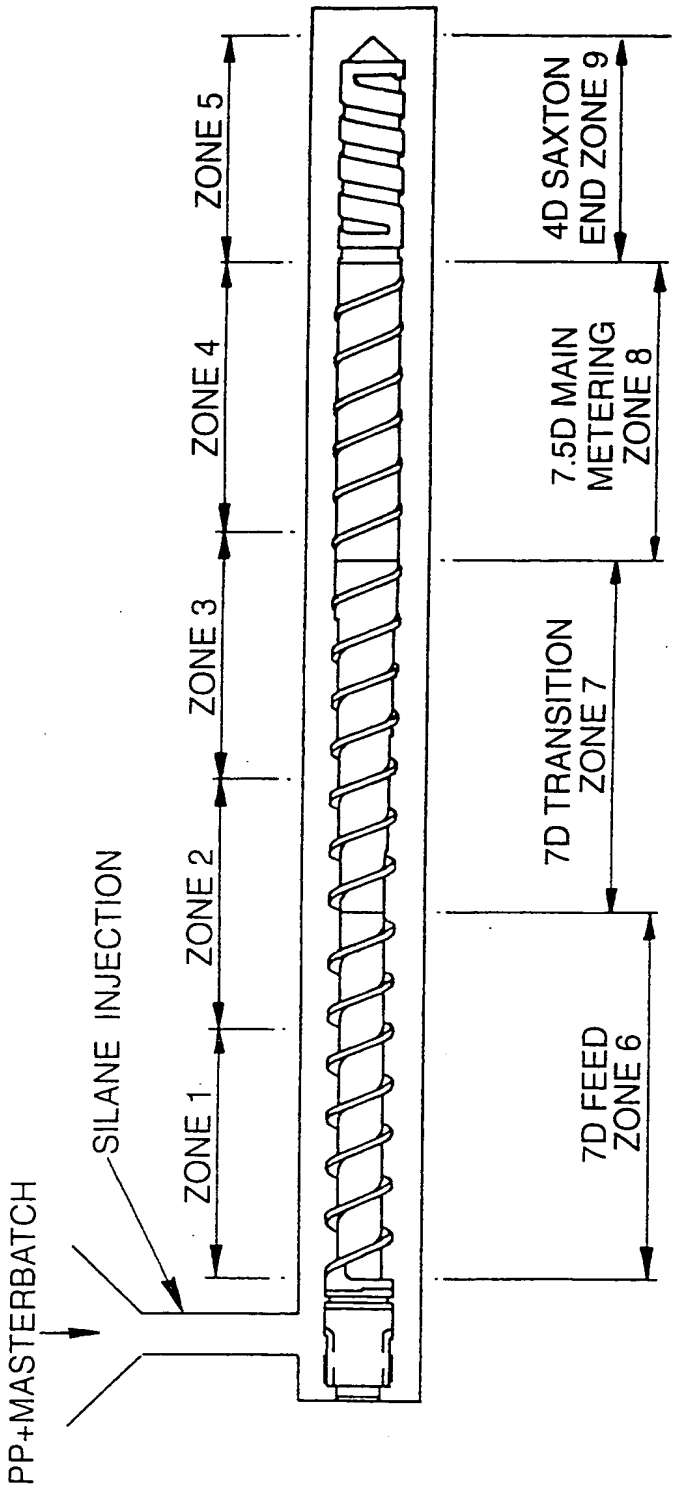
PP+MASTERBATCH
SILANE INJECTION
ZONE 1
ZONE 2
ZONE 3
ZONE 4
ZONE 5
7D FEED ZONE 6
7D TRANSITION ZONE 7
7.5D MAIN METERING ZONE 8
4D SAXTON END ZONE 9

Cable-making Process

This invention relates to a process for use in making electric cables, and more particularly polymeric power cables having insulation of an ethylene homopolymer or copolymer crosslinked *via* silane groups and having a semiconducting dielectric screen (or outer shield) on the outside surface of the insulation. Normally such cables will have at least one load-carrying conductor of copper or aluminium, a semiconducting conductor screen (or inner shield) between this conductor and its insulation, and an enclosing sheath (or jacket) of metal, polymeric material, or a composite.

The present invention relates particularly to the manufacture of the dielectric screen of such cables.

The dielectric screen of a cable needs to adhere strongly enough to the insulation to minimise the risk of voids occurring at the interface, but needs to be removed without leaving a conductive residue and ideally without removing any insulating material where the cable is jointed or terminated, and a preferred class of dielectric screen (IEC 502) is designated "strippable", indicating that it can be cleanly stripped from the insulation by peeling and does not require the use of cutting tools between the screen and the insulation or of abrasives.

Strippable screens for cables in which the insulation is crosslinked *via* silane links (introduced by grafting hydrolysable silane groups into the polymer and then, after the insulation (and normally each of the screens) has been applied to the conductor exposing it to the action of moisture and a silanol condensation catalyst conventionally use polypropylene blended with an ethylene copolymer (usually EVA) as polymer base to get the required bond strength in

combination with high enough tensile strength, tear strength and deformation resistance at processing temperature to meet the requirements of the application. In current practice, cable-makers buy in a screen composition, and this is expensive because of the technical difficulties of processing both polypropylene and carbon black, an din particular the need for scrupulous cleaning of the blending equipment after production of relatively small volumes of the compound. On-line compounding has been considered (for instance, *Research Disclosure*, **371** March 1995, page 228, item no 37155) but has not so far been found practicable.

In accordance with the present invention, an on-line compounding process for making a strippable screen in the manufacture of an electric power cable having insulation of an ethylene homopolymer or copolymer crosslinked *via* silane links comprises:

feeding to an extruder

(a) a preformed composition comprising an ethylene copolymer and carbon black;

(b) particulate polypropylene; and

(c) crosslinking agents comprising an unsaturated hyrolysable silane, a grafting initiator and a silanol condensation catalyst;

mixing these ingredients and generating pressure in the resulting mixture in a first zone of the extruder at a temperature above the softening range of the copolymer but substantially below the softening range of the polypropylene so that it is dispersed in the solid state into the plastified copolymer;

and only after the crosslinking agents at least are dispersed through the mixture raising the temperature of the

mixture in a second section of the extruder above the softening range of the polypropylene and sufficient to initiate grafting of silane side-chains to the copolymer and blending to further disperse the now molten polypropylene.

The blending step is preferably performed by a "Saxton" mixing section of the extruder screw, but other suitable mixing apparatus (for example a cavity-transfer mixer) can be used. The pressure generated by the first section of the extruder, where the polypropylene is solid, is available to maintain flow through the remainder of the extruder.

Once blended, the composition should be immediately applied to the insulation of the cable, preferably by co-extrusion with the insulation and the conductor screen in a "triple" extrusion head.

Preferably the copolymer is EVA and the crosslinking additives are also conventional - that is either vinyl trimethoxy silane or vinyl triethoxy silane, a suitable peroxide and dibutyltin dilaurate - but alternative reagents that have been proposed can generally be used if desired.

The invention will be further described, by way of example, with reference to the accompanying drawing which is a diagrammatic representation of an extruder for carrying out the process of the invention.

A preformed blend ("masterbatch") comprising (by weight) 20 parts conductive carbon black, 79.4 parts EVA and 0.6 parts of a conventional antioxidant is preformed and is fed as granules to the hopper of the extruder, as is granular polypropylene at the rate of 27.4 parts; a liquid "cocktail" of crosslinking agents is injected to the base of the hopper at the rate of 1.25 parts. This cocktail comprises (by weight) 1 part of a peroxide grafting initiator with an

activation temperature of 190°C, 0.36 parts of dibutyltin dilaurate and 10.93 parts of silane acting as solvent.

The extruder has five thermal zones 1-5 (top of figure), of which the zones 1 and 2 are maintained at 130°C and 140°C respectively and constitute the first zone in accordance with the invention: the temperature of the polymer mix in these zones is estimated as about 10°C higher than the set temperature indicated because of shear heating, but is still well below 160°C, the melting-point of the polypropylene (for example, Hoechst 1780SI). In thermal zones 1-2 the EVA masterbatch is plastified, the polypropylene dispersed in it as solid particles and the crosslinking cocktail evenly distributed; enough pressure is generated in the mix to propel it through the extruder (in conjunction with the relatively small effect of the remainder of the extruder). The third thermal zone is transitional, the set temperature being 160°C and the mix temperature estimated at 170°C by the time it reaches the end of the zone; in this zone, the polypropylene is melted but not fully dispersed and the grafting reaction is initiated but not completed. Thermal zones 4 and 5 are set at 190°C and 200°C respectively, and the estimated mix temperature in these zones is estimated to be about the same as the set values.

Structurally (bottom of figure), the extruder comprises four zones distinguished by the structure of the screw: first a feed zone 6, then a transitional zone 7 leading to a "metering" zone 8, the primary function of which in the present invention is to provide sufficient dwell time for the grafting reaction to be completed in the extruder (not fully in this zone) and finally a blending zone 9 of the "Saxton" type comprising many minor flights and channels of long pitch compared with the remainder of the screw, interrupted by

major channels of reverse hand to effect distributive mixing and break up laminar flow.

CLAIMS

1 An on-line compounding process for making a strippable screen in the manufacture of an electric power cable having insulation of an ethylene homopolymer or copolymer crosslinked *via* silane links comprising:

feeding to an extruder

(a) a preformed composition comprising an ethylene copolymer and carbon black;

(b) particulate polypropylene; and

(c) crosslinking agents comprising an unsaturated hyrolysable silane, a grafting initiator and a silanol condensation catalyst;

mixing these ingredients and generating pressure in the resulting mixture in a first zone of the extruder at a temperature above the softening range of the copolymer but substantially below the softening range of the polypropylene so that it is dispersed in the solid state into the plastified copolymer;

and only after the crosslinking agents at least are dispersed through the mixture raising the temperature of the mixture in a second section of the extruder above the softening range of the polypropylene and sufficient to initiate grafting of silane side-chains to the copolymer and blending to further disperse the now molten polypropylene.

2 A process as claimed in claim 1 in which the blending step is performed by a "Saxton" mixing section of the extruder screw.

3 A process as claimed in claim 1 or claim 2 in which the copolymer is EVA and the crosslinking additives are either vinyl trimethoxy silane or vinyl triethoxy silane, a peroxide and dibutyltin dilaurate.

4 A process as claimed in any one of claims 1-3 in which the composition, once blended, is immediately applied to the insulation of the cable, by co-extrusion with the insulation and the conductor screen in a "triple" extrusion head.

5 5 An on-line compounding process for making a strippable screen in the manufacture of an electric power cable having insulation of an ethylene homopolymer or copolymer crosslinked *via* silane links substantially as described with reference to the drawing.

The Patent Office

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Application No: GB 9719255.3
Claims searched: 1-5

Examiner: Monty Siddique
Date of search: 18 November 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): B5A (AC, AD32, AT17D, AT17J, AT17R); C3M (ML)

Int Cl (Ed.6): B29C 47/00 47/38 47/60 47/62 47/64; C08L 43/04

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
Y	GB 1367083	(DUNLOP...) Entire document: page 1 lines 28-30, 41/42, 50/51; claim 1 etc; dispersing particulate polypropylene in plasticised ethylene copolymer followed by heating above softening temperature of particulate propylene	1 at least
Y	GB 1246222	(SUN OIL...) Page 2 line 118-page 3 line 10; page 3 lines 21-24; claim 1 etc; similar principle as that in GB '083	1 at least
A	WO 88/01227 A1	(ALZNER...)	
Y	US 5384369	(BASF...) Column 6 lines 17-31; column 7 lines 44-49 etc; cross-linking reaction taking place inside the extruder	1 at least
Y	RD 37155, 31 March 1995, page 228; item no. 37155.		1 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.